

THE STOCKPILE STEWARDSHIP PROGRAM

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Subcommittee on Military Procurement
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INTRODUCTION

Mr. Chairman and members of the committee, thank you for the opportunity to provide a statement on the status and future of the Stockpile Stewardship Program. Dr. Michael Anastasio is appearing before the committee today in my absence. He is currently Deputy Director for Strategic Operations and was recently appointed to succeed me as Director of Lawrence Livermore National Laboratory, effective July 1, 2002.

Livermore is committed to maintaining confidence in the U.S. nuclear weapons stockpile as a principal participant in the nation's Stockpile Stewardship Program. The Laboratory is also engaged in vital national programs to reduce the threat posed by the proliferation of weapons of mass destruction and to provide for homeland security. My message to you about the status and future of the nation's Stockpile Stewardship Program is consistent with my previous testimonies before this committee:

- A strongly supported, sustained Stockpile Stewardship Program has an excellent chance of ensuring that the U.S. can maintain the safety, security, and reliability of the stockpile in the absence of nuclear testing. It is an extremely demanding program from both technical and managerial perspectives with ambitious goals and risks yet to be faced.
- So far stockpile stewardship has achieved many successes: certification of the W87 ICBM warhead, which was refurbished through a Stockpile Life Extension Program that has been an exemplary laboratory-plant partnership; ongoing development of a quantitative methodology to provide the basis for weapon certification and program decisions; the development and use of increasingly sophisticated stockpile surveillance capabilities; greatly improved understanding of many aspects of nuclear weapon performance as a result of an aggressive program of simulations and nonnuclear experiments; and substantial progress in acquiring the capabilities needed for the program to succeed in the long run.
- However, the toughest challenges lie ahead as weapons continue to age and other issues and requirements for the stockpile arise. There are currently many competing demands on the Stockpile Stewardship Program that must be balanced in order to succeed. At the same time, the program needs to become more flexible and agile so that it will be able to deal with surprises, which are sure to come.

My testimony amplifies on these points. First, I discuss the need for a sustained, balanced Stockpile Stewardship Program and efforts under way to enhance NNSA's capabilities to develop and execute a balanced program. Second, I highlight selective

accomplishments of the program to illustrate that considerable progress is being made on many fronts. Finally, I discuss the challenges that lie ahead.

A SUSTAINED, BALANCED PROGRAM EFFORT

The Stockpile Stewardship Program continues to be extremely challenging. It needs both strongly sustained support and balance for continued success in the long term. There are competing demands on the program. The central focus of the Stockpile Stewardship Program is on stockpile readiness—maintaining the weapons, monitoring their condition, and refurbishing or replacing weapon components as necessary. To meet these needs, the program is expeditiously putting into place a set of vastly improved scientific tools and modern manufacturing capabilities, which are crucial for stockpile readiness in the near- and long-term. These capabilities include 100-teraops supercomputers, advanced radiography capabilities to take three-dimensional images of imploding mock primaries, a high-energy-density experimental facility (the National Ignition Facility) to study the thermonuclear physics of primaries and secondaries, and efficient and flexible manufacturing facilities.

These investments in the capabilities for stockpile stewardship are very demanding of resources. So is the need to meet the near-term requirements of the Department of Defense (DoD) through stockpile life extension programs. In addition, as pointed out in the 2002 Nuclear Posture Review, new weapons capabilities, not present in the current stockpile, may be needed to meet future post-Cold War threats. Accordingly, exploratory work on advanced weapons concepts should be part of the overall program. Finally, on top of all these specific demands on the program, we need some flexibility in the Stockpile Stewardship Program to respond to surprises. The history of the weapons programs is that every so often something unanticipated arises that puts an extra demand on resources.

General John Gordon, Administrator of NNSA, is taking a number of actions to enhance NNSA's performance and improve processes for long-term planning and budgeting, which are critically important to the development and execution of a balanced Stockpile Stewardship Program. One key change is the annual development of the integrated Future-Year Nuclear Security Plan (FYNSP). With this five-year plan, NNSA is better able to make program trade-offs, which involve adjustments to future-year budgets, and it helps our Laboratory in resource, workload, and facility planning by providing a more reliable future program base. In addition, we expect that the organizational changes in NNSA, clarification of lines of authority and responsibility, and steps to reduce inefficiencies and excessive administrative workload will improve the effectiveness of programmatic efforts.

As the two nuclear design laboratories, Lawrence Livermore and Los Alamos are working with our contractor, the University of California, to strengthen management accountability, institute more uniform best practices in operations at the two laboratories, and better integrate our efforts in the Stockpile Stewardship Program. While it is essential to preserve the independent assessment capability of a two-laboratory system, there are many aspects of stockpile stewardship where we share capabilities and load-level the work. It is our joint responsibility to ensure that there are no significant gaps in nuclear design capabilities and expertise, that important program milestones are met, and that inefficiencies in effort are minimized.

PROGRAM ACCOMPLISHMENTS

To date, the Stockpile Stewardship Program has many accomplishments—we are largely on track. It has been a team effort that has benefited from capabilities, expertise, and hard work across the NNSA complex—headquarters and the field, the three laboratories,

the production facilities, and the Nevada Test Site. My testimony describes several example accomplishments where the Laboratory's efforts were directly involved.

The W87 Life Extension Program

In April 2001, Lawrence Livermore and Sandia national laboratories completed formal certification of the W87 ICBM warhead, which is undergoing a life-extension program (LEP) so that it may remain part of the enduring stockpile beyond the year 2025 and meet anticipated future requirements for the system. The W87 in the Mk21 reentry vehicle is planned as a single RV option for the Minuteman III ICBM. The first production unit was completed at the Pantex Plant in February 1999, and production is proceeding on schedule for completion early in 2004.

This first completed certification of a warhead refurbished through an LEP is a groundbreaking milestone for the Stockpile Stewardship Program. The program was an outstanding team effort with the Air Force, and it demonstrated effective partnership of the laboratories and the production facilities to overcome physics, engineering, and manufacturing challenges to meet Department of Defense requirements without conducting a nuclear test. The development activities for this program included extensive flight testing, ground testing, and physics and engineering analysis. High-fidelity flight tests, incorporating the latest technological advances in onboard diagnostic instrumentation and telemetry, provided added confidence in the reliability of the design modifications. Assessment of nuclear performance is based on computer simulation, past nuclear tests, and new above-ground experiments that addressed specific physics questions raised by the engineering alterations and computer simulations.

The W87 certification process was detailed and thorough. It included extensive formal peer and expert reviews by laboratory, NNSA, and DoD personnel. Confidence in the results was greatly strengthened by the use of a rigorous quantitative methodology as a basis for the certification. This methodology is discussed below.

Certification and Assessments

To maintain the nuclear stockpile and to be responsive to evolving policy, we must be able to ensure with confidence the safety and performance of aged and/or refurbished warheads against their military requirements. One vital process to build this confidence is Annual Certification. It is based on advice from the laboratory directors, the commander-in-chief of the U.S. Strategic Command, and the Nuclear Weapons Council to the Secretaries of Energy and Defense developed from the technical evaluations made by the NNSA laboratories. The sixth Annual Certification cycle was completed in 2001. We are well into the seventh and find ways to improve the process each cycle.

In the course of Annual Certification, our Laboratory collects and reviews all available information about each stockpile weapon system for which LLNL has design responsibility, including physics, engineering, and chemistry and materials science data. This work is subjected to rigorous, in-depth review by scientists, engineers, and managers throughout the program—including the use of “red teams.” In addition, the Laboratory's work is reviewed by USSTRATCOM's Stockpile Assessment Team, which provides a very valuable critique, and several other DoD groups.

For the assessments underpinning Annual Certification and the formal certification required for modified units of previously certified and tested weapons, the key question has transformed from “will it work?” to “when does it fail?”. When nuclear testing is not available, these certifications will be based on a much more extensive range of above-

ground testing, together with a vastly improved simulation capability. The existing nuclear test database is a crucial resource for challenging the validity of these improved codes. Ultimately, expert judgment informed by the best available data will always be at the core of the certification process.

Quantification of Margins and Uncertainties (QMU). For these certification actions, it is essential that we use a rigorous set of quantitative standards, which is technically sound—to establish our own confidence—and which provides transparency to the government and military—to build their trust and confidence in us. The methodology used in this process is called the quantification of margins and uncertainties (QMU).

These standards are based on ensuring that adequate margins exist against limited uncertainties for each sensible way that the warhead can fail to function properly (analogous to the engineering safety factors used in building a bridge). Margins must be adequate whether the concerns are driven by aging, remanufacturing, possible design or manufacturing flaws, or new requirements for the warhead.

For each issue, we gather data and conduct simulations to determine how close we are to the margin of failure and estimate uncertainties. This process entails the efforts of many experts, extensive peer group review, and careful scrutiny by “red teams”. The outcome is quantitative confidence factors that can be used as a basis for judgments. Livermore first applied the QMU methodology to the certification of the W87 life extension program. It is being further developed and jointly implemented by Livermore and Los Alamos as a single national certification process.

QMU can also help provide prioritization for the laboratory’s technical efforts and for the overall Stockpile Stewardship Program, for example where to invest in capabilities to raise confidence in weapon performance. That is, QMU can help provide direction for efforts to improve weapon surveillance and for the Science and Engineering Campaigns.

The Laboratory Director’s Responsibility. As mentioned, the use of QMU helps to focus attention on aspects of weapon design and engineering that matter most to overall performance. The methodology and considerable amount of data gathered that is required for its implementation are amenable to thorough review—expert opinion and a multiplicity of viewpoints are an absolutely necessary part of the process. However, in the end, certification is a judgement issue that ultimately rests on my shoulders. It is my responsibility as laboratory director.

Enhanced Surveillance

Our stockpile surveillance efforts focus on assessing the condition of weapons in the stockpile and on understanding the effect of aging on them. Aging is important because it affects the physical characteristics of materials, and we must determine how these changes impact weapon safety and performance. With a better understanding of aging, we can help to avoid surprise. More predictive stockpile surveillance makes possible systematic refurbishment and preventative maintenance activities to correct developing problems when necessary. The workload at the production facilities can be better managed if burdensome refurbishment of components that are not in danger of failing can be avoided. An important factor here is to be able to detect subtle changes to the weapon system well in advance of the change causing a safety, reliability, or performance issue. This is essential to prepare for and balance the workload for upgrades or life extension efforts that may take many years to fully implement.

We continually review and upgrade our surveillance programs as we gather more data, gain experience, and refine sampling plans. We also measure additional attributes as new tools become available and the need for more information arises. We are now taking on responsibility for surveillance of pits from Livermore-designed weapons in the stockpile to better balance the workload. These activities had been conducted at Los Alamos.

In addition, we are making major improvements to the sensors and techniques used to inspect weapons. Newly emerging diagnostics—including some that do not require destruction of the weapon—are enabling us to better quantify the condition of the stockpile and to identify aging characteristics at the earliest possible time. Better surveillance capabilities can help avoid unnecessary refurbishment work at the plants. For example, Livermore, in cooperation with Y-12, has completed the development of an analytical model and the development and deployment of a suite of diagnostic tools that enable us to understand the aging behavior of secondary assemblies. We are also completing development of high-resolution x-ray tomography for imaging weapon pits; first phase deployment at the Laboratory is complete, and deployment at Pantex is continuing. Furthermore, development continues on high-energy neutron radiography for nondestructively detecting small voids and structural defects in weapon systems.

Understanding Plutonium

One of the major success stories of the Stockpile Stewardship Program is the significant improvement we are making in understanding the properties of plutonium. This is a very important issue—we need to understand aging in plutonium and the effect of aging-related changes on the performance of an imploding pit of a stockpiled weapon. The required capacity of the production complex depends on the anticipated lifetime of plutonium pits in the stockpile. An accurate assessment is necessary. If we underestimate the lifetime of pits, we may overinvest in facilities to remanufacture plutonium parts. If we overestimate the lifetime of pits, the nation could find itself critically short of capacity for plutonium operations when it is vitally needed.

To study the highly complex properties of plutonium, we have combined advances in theoretical modeling with the use of sophisticated experiments. For example, we are using advanced materials characterization tools such as our Transmission Electron Microscope, the most powerful such instrument in the NNSA complex, to study how aging plutonium accommodates the helium that is created through self-irradiation. We are also using old pits and accelerated-aging alloys to determine the lifetime of pits. Accelerated-aging samples are plutonium alloys with a mixture of isotopes to increase the rate of self-irradiation damage so that the material “ages” faster. Furthermore, Livermore is conducting sub-critical experiments at the Nevada Test Site (NTS) to investigate the properties of plutonium shocked and accelerated by high explosives. NTS is also site of the Joint Actinide Shock Physics Experimental Research (JASPER) Facility, a two-stage gas gun for performing shock tests on special nuclear materials. Now that construction is completed, JASPER will complement other experimental and modeling activities by providing scientists more precise equation-of-state data at extreme conditions than can be obtained from other types of experiments.

Capabilities for Weapon Assessments and Certification

Assessments of weapon performance and certification of weapon refurbishments must be based on scientific and engineering demonstration to be credible. In the absence of nuclear testing, we rely on data from past nuclear tests as a benchmark, component-level experiments and demonstration, and advanced simulations for an assessment of weapon performance and safety that is integrated through use of the QMU methodology. This

approach has enabled us to successfully certify the W87 life-extension refurbishment and address stockpile issues that have emerged to date. However, as the stockpile ages, we anticipate that more difficult issues will arise.

These needs—to be able to assess and certify both weapon performance and refurbishment actions—drive the Stockpile Stewardship Program’s investments in much more capable experimental facilities, such as the National Ignition Facility (NIF), the Dual Axis Radiographic Hydrodynamic Test Facility and even more advanced hydro-test capabilities, and greatly enhanced numerical simulation tools developed through the Advanced Simulation and Computing (ASCI) program. Here, the discussion focuses on three areas where significant improvements in capabilities are completed or under way at Livermore: the Contained Firing Facility, ASCI, and NIF.

The Contained Firing Facility. Hydrodynamics testing is the most valuable experimental tool we have for diagnosing device performance issues for primaries in stockpiled weapons. Through hydrodynamics experiments conducted at Livermore’s Site 300 and the Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) at Los Alamos, weapon scientists are able to characterize the energy delivered from the high explosives to a mock pit, the response of the pit to hydrodynamic shocks, and the resulting distribution of pit materials when they are highly compressed. This information is critical for baselining weapons, certifying stockpile performance, and validating hydrodynamics simulation codes.

Over the past decade, we have made tremendous advances in diagnostics capabilities and experimental techniques used in hydrodynamic testing. We are now able to gather far more revealing data from hydrodynamic tests than was possible when we developed the weapons that are now in the stockpile. The most sophisticated type of hydro experiment is the “core punch,” in which scientists use high-energy radiography to record a digital image of the detailed shape of the gas cavity inside a pit when it is highly compressed. In 1998, we carried out at Livermore’s Flash X-Ray Facility the first core punches on two important stockpile primary devices: the W76 SLBM warhead and the B83 strategic bomb.

An upgrade of the Flash X-Ray Facility was completed last year with the addition of the Contained Firing Facility. The project was completed on time, on budget. Qualification testing has been completed to assure its ability to contain debris from experiments that use up to 60 kilograms of high explosives. The first stockpile-related experiment was executed in March 2002. Livermore is now able to conduct these critically important experiments with isolation from the surrounding environment.

ASCI and the ASCI White Computer. The Advanced Simulation and Computing (ASCI) program is central to many of the success stories of the Stockpile Stewardship Program. ASCI has steadily progressed from efforts to develop weapons physics and engineering codes that run efficiently on the new computers to a resource that the LEPs are counting on to meet important milestones. As we continue to get larger and faster machines and better simulation models, the ASCI capabilities we have are “deployed” in support of a wide range of Stockpile Stewardship Program deliverables.

In summer 2000, we took delivery from IBM of ASCI White, at the time the world’s most powerful computer, capable of 12.3 teraops (trillion operations per second). This machine has been successfully used and shared since early 2001 by all three NNSA laboratories—Sandia and Los Alamos were extremely effective in using it by computing at a distance. To meet each laboratory’s requirements to run problems, calculations were interleaved in an integration schedule for the machine.

Both Livermore and Los Alamos used ASCI White to complete in late 2001 the first-ever prototype fully three-dimensional simulations of a complete warhead explosion. The size and scale of ASCI White allowed the two laboratories to employ a level of spatial resolution and depth of physics models that were heretofore completely beyond reach in 3D. Sandia also used ASCI White to perform structural dynamics calculations for different environments that weapons might encounter. One terabyte of core memory was used on each structural dynamics calculation in simulations that were completed in late September 2001 and set many world records. The speed, large memory, and stability of White were essential elements contributing to these successful series of calculations.

ASCI White is more than fully subscribed, and new capabilities are soon to be delivered to Los Alamos and Sandia. Livermore is earmarked to take delivery of its next ASCI computer in FY 2004, a machine that will be capable of 60 to 100 teraops. It will move us much closer to ASCI's goal of full-scale simulation of weapons performance using advanced physics models with data derived from extensive, first-principles physics simulations. The groundbreaking ceremony for construction of the Terascale Simulation Facility (TSF) to house this computer was held April 4, 2002.

The National Ignition Facility (NIF). The High Energy Density Physics (HEDP) effort is a critical element of the Stockpile Stewardship Program. It is the source of experimental data to support ongoing LEPs and data to support the longer-term effort to provide predictive capability and quantitative measures for warhead certification into the future. The National Ignition Facility (NIF) is the central experimental facility in the HEDP Program. Housing a 192-beam laser and associated experimental capabilities, NIF will be the world's largest laser, delivering 60 times more energy density than the Omega laser at the University of Rochester (and the previous Nova laser at Livermore), currently the largest laser in the HEDP program.

NIF is the only stewardship facility that will provide experimental conditions relevant to fusion burn, a critical process in the operation of a nuclear weapon. NIF will be capable of addressing underlying physics issues associated with our stockpile weapons, and the ability to conduct integrated experiments at weapons-relevant temperatures and pressures. These integrated NIF experiments will allow us to experimentally validate our computational capabilities, under conditions more closely matched to those encountered in actual underground tests. In addition, NIF will be an important tool for evaluating the judgement of the stewards, based on the ability to predict, or not, the outcome of complex weapons-relevant experiments.

Construction is continuing on NIF. Overall the NIF project is more than 60% complete. In September 2001 the NIF conventional facilities construction, a \$270 million project, was completed on schedule and on budget. In May 2002, the Project completed installation of one-half of NIF's beampath infrastructure. Now in place are the precision-cleaned enclosures for the components of 96 laser beams. In addition, we continue to make outstanding technical progress on NIF's optical systems. Great progress has been made on the development of new optics polishing techniques that can reduce the damage potential of NIF optics much more than our requirements. We are currently implementing these new techniques at our vendors to provide the first optics for NIF's final focusing systems.

The baseline plan and schedule for NIF was included in General Gordon's certification of the NIF project, provided to Congress on April 6, 2001. The schedule provides for project completion at the end of FY 2008, and the NIF team's goal in the coming year is to achieve "first light" by delivering four laser beams to the target chamber. Experimental plans have been developed to utilize the NIF as it is brought on line. These early experiments have been designed to provide data to support LEP activities and to begin to

provide some of the data required to improve our ability to determine margins against credible failure modes. As commissioning of laser beams continues, NIF will quickly become the workhorse experimental facility in the HEDP program.

PROGRAM CHALLENGES

Many major milestones have been achieved in the Stockpile Stewardship Program, but difficult challenges lie ahead as weapons continue to age and the possibility of new requirements for stockpiled weapons arise. A full spectrum of capabilities for stockpile stewardship is required for long-term success.

First, to recognize and evaluate aging issues (and other defects) in weapons and devise remedies before they become problems, we must understand in detail the science and technology that govern all aspects of nuclear weapons. We are making progress here, but we need even better investigative tools. Enhanced surveillance capabilities and a better understanding of aging effects in weapon components will help to avoid surprise and provide a longer lead to time for refurbishment actions.

The nuclear weapons production complex must be flexible and able to remanufacture parts and refurbish weapons as needed. There will be requirements for new weapon components. Investments in production facilities are required to support urgently needed refurbishment actions in current LEPs and to begin to deal with widespread obsolescence in the production complex. The plants need efficient and modern means for manufacturing weapon components. In addition, we need to proceed expeditiously with studies of plutonium aging and the W88 Pit Manufacturing and Certification Integrated Project. These efforts will provide an informed basis for future decisions about a plutonium pit production capability.

We also must be responsive to new requirements and prepared to deal with surprises. DoD requires that NNSA retain the capability to design, develop, and produce new-design nuclear warheads. By engaging in studies and exploratory research and development for advanced weapon concepts, we can exercise weapon development capabilities, help to avoid surprise and understand threats, and become better positioned to respond to new weapon requirements should they emerge. In addition, these activities will serve to train new designers and engineers, and they will reinforce ties to DoD and its contractors. Interactions with the plants about manufacturing issues will also be beneficial.

Since the future is uncertain and surprises do occur, we need nuclear-test readiness. In conjunction with the other laboratories and the Nevada Test Site, Livermore is participating in NNSA's examination of measures that can be taken to shorten the time between a decision to conduct a nuclear test and the event. Together, we need to determine the longest lead-time items and costs to shorten them in order to make reasonable trade-off decisions to cost-consciously improve readiness.

The nation must be confident in the results of Annual Certification and our assessments of the performance of aging and refurbished warheads as well as any new weapons that are developed. Expert judgement is required, backed by experimental data, the results of validated simulation models, and application of a rigorous, quantitative certification methodology. We need to press ahead to further refine and fully implement the QMU certification methodology together with acquisition of advanced computation and experimental facilities: more powerful ASCI computers, modern laboratory experimental facilities, NIF and DARHT, and then an advanced hydrotest facility. These capabilities are essential elements of the Stockpile Stewardship Program's Campaigns and efforts to

improve our fundamental understanding of nuclear weapons, which are essential for assessments and certification.

Finally, acquisition of this spectrum of capabilities is time urgent to meet existing requirements for weapon refurbishment and to deal with other weapon performance issues as they arise. At the same time, the LEP workload is substantial, and the program needs to become more flexible and agile so that it will be able to deal with surprises, which are sure to come. There are currently many competing demands on the Stockpile Stewardship Program that must be balanced in order to succeed.

Program balance depends on having strong, sustained support for the Stockpile Stewardship Program, and we are benefiting from this committee's continuing support. Program balance also depends on having quality leadership by the NNSA management team, effective systems and tools for comprehensive program planning, and efficient program execution. We are pleased with General Gordon's actions to provide NNSA clear direction, make necessary organizational changes, improve long-term planning and budgeting, and make NNSA a more effective and efficient organization. We are already seeing some benefits from these actions and expect to see more in coming years.

CLOSING REMARKS

The Stockpile Stewardship Program continues to make excellent technical progress in many areas, some of which I have highlighted here: notably, the W87 ICBM warhead life extension, completion of the Contained Firing Facility, progress on construction of the National Ignition Facility, use of the ASCI White supercomputer and future ASCI plans at Livermore, and selected scientific and technical achievements that are improving our understanding of the aging of nuclear weapons and weapon performance. However, many difficult challenges lie ahead. There are many competing demands on the program that must be balanced in order to succeed. Stockpile stewardship continues to be an ambitious, extremely demanding program from both technical and managerial perspectives. Nevertheless, I believe that a strong, sustained Stockpile Stewardship Program will succeed in maintaining the safety, security, and reliability of the nation's nuclear deterrent over the long term. Achieving that goal depends on your strong, sustained support for the program, effective and efficient management of it by NNSA, flexible and agile production capabilities, and continuing scientific and technical excellence in pursuit of stockpile stewardship at the NNSA laboratories.

Finally, as you are aware, I will be leaving my position as laboratory director soon. I appreciate the support that this committee has provided to Lawrence Livermore and to me during my tenure. I also appreciate having had the opportunity to serve our nation in this manner. I look forward to the very positive future that I believe Lawrence Livermore will have with your continued support.

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